ORIGINAL

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

1995

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| In the Matter of | ) | |
| | ) | |
| Preparation for International | ) | |
| Telecommunication Union World | ) | IC Docket No. 94-31 |
| Radiocommunication Conferences | ) | |

To: The Commission

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## CONSOLIDATED REPLY TO OPPOSITIONS TO PETITION FOR PARTIAL CLARIFICATION AND RECONSIDERATION

The Association of American Railroads ("AAR"), by its attorneys, hereby responds to the "Opposition to the Petition for Partial Clarification and Reconsideration" ("Opposition") filed by Constellation Communications, Inc. ("Constellation") and the Opposition filed by Loral/QUALCOMM Partnership, L.P. ("Loral"). Constellation and Loral opposed AAR's Petition which urged the Commission to reconsider its proposed allocation of the upper 6 GHz band for MSS feeder links in light of the severe congestion problem at 6 GHz which will be magnified by the impending fixed service ("FS") relocation. The two MSS applicants also opposed AAR's request for further clarification of the Commission's commitment to and protection of FS users facing displacement from the 2 GHz band to the 6 GHz band.

### A. Background

Both the Telecommunications Industry Association ("TIA") and Alcatel Network Systems ("Alcatel") filed comments with the Commission to voice their strong support for AAR's Petition. TIA explained that the proposed allocation of the upper 6 GHz

band to MSS feeder links would have a "disastrous impact...on the FS industry and on the PCS industry" because of the already congested nature of the band and the fact that "key users of the upper 6 GHz band are considering radical expansion plans for their microwave systems."[1]

TIA's pleading makes it clear that the impact of an allocation at 6 GHz to MSS feeder links extends far beyond the FS users alone. The PCS industry, which bears the financial and regulatory responsibility for relocating FS users out of the 2 GHz band, will face significantly increased relocation costs if, due to congestion and interference caused by MSS feeder links at 6 GHz, it will have to look for higher bands at which to relocate the displaced FS systems. In a Statement of Non-Concurrence filed earlier in this proceeding the FS community stated that sharing the 6 GHz band with MSS feeder links would result "in more constraints on the FS users than they currently experience with their FS links at 2 GHz" and added that,

> The adverse consequences of such a result would be very serious, not so much for the 2 GHz FS incumbents as for the "new technology" entities, such as the PCS and MSS providers which are planning to use the 2 GHz frequencies. This problem will occur because the requirement that the FS incumbents vacate the 1850-2200 MHz band was made specifically dependent upon the availability to them of comparable replacement facilities in higher bands.[2]

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[1] TIA Comments in support of AAR's Petition at 2 (filed August 10, 1995).

[2] Statement of Non-Concurrence with the Industry Working Group 4 ("IWG-4") Final Report filed on May 16, 1995, by Alcatel, the American Petroleum Institute ("API"), the Associated Public Safety Communications Officials International ("APCO"), AAR, AT&T, Harris Corporation-Farinon Division, TIA, and UTC-The Telecommunications Association ("UTC") at 7.

Thus, the breadth and diversity of the affected parties highlights the need for the Commission to reconsider its proposed allocation of the upper 6 GHz band for MSS feeder links.

The need for caution in making additional allocations is also evident in the FS users' need for guaranteed system reliability. Alcatel expressed the concern of FS users who rely on their communications systems for the provision of critical services, such as for public health and safety purposes, that the allocation of the 6 GHz band for MSS feeder links would threaten FS requirements for "very high path reliability (e.g., 99.999% or higher)."[3] Alcatel concluded that "[u]p to a 30% decrease in available spectrum in the upper 6 GHz band, and severe path degradation, could plague FS users if they are made co-primary with NGSO MSS feeder links."[4] This conclusion is based on a comprehensive technical analysis which demonstrated that if the 6 GHz band is allocated for MSS feeder links, "50 MHz, or 28% of the upper 6 GHz band, will become unavailable for FS users due to channel pairing requirements."[5]

B. The Oppositions of Loral and Constellation Ignore Evidence That Sharing is Not Feasible and Fail to Respond Adequately to Legitimate FS Concerns

The Oppositions of both Constellation and Loral failed to address the major concerns of the FS users as discussed above. Constellation claimed that because of

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[3] Alcatel Comments in Support of AAR's Petition at 3 (filed August 10, 1995).

[4] Id. at 4.

[5] The technical analysis (submitted as Appendix A to the Statement of Non-Concurrence and attached hereto) explained that this problem results from ITU requirements for maximum coordination distances and for coordination for the entire band. Statement of Non-Concurrence at 5.

power flux density limits on satellite transmissions, "there will not be any adverse impact of terrestrial fixed facilities in the 6 GHz band."[6] The FS community, however, has already referenced both an Inmarsat study and a Canadian contribution to the CPM (ITU document CPM 95/22-E, dated 27 March 1995), which show that a power flux density limit of -154/-144dB($W/m^2$/4kHz) could degrade the performance of the 11,000-plus U.S. upper 6 GHz existing microwave links by 10 to 25%.[7] Because of this level of degradation, systems facing relocation from 2 GHz will not find comparable replacements at 6 GHz.[8]

Furthermore, while Constellation acknowledged that there could be interference "from the terrestrial fixed service into the feeder link earth station receivers," it ignored the fact that this susceptibility of satellite earth station receivers to interference severely constrains the ability to locate FS equipment near satellite earth stations,[9] which will in turn threaten essential operational flexibility for FS users. For example, in the case of the railroads, the routes of the railroad right-of-way and the placement of rail yards dictate the location of the majority of the railroads' communications systems. Any

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[6] Constellation Opposition at 2 (filed August 10, 1995).

[7] See Statement of Non-Concurrence at 8. The Statement of Non-Concurrence also pointed out that the Inmarsat study demonstrated that "6 GHz diversity systems, likely to replace long 2 GHz links, will be more sensitive to interference than non-diversity ones." Id.

[8] Id.

[9] Late Further Reply Comments in IC Docket 94-31 filed on behalf of Alcatel, API, AAR, APCO, AT&T, Harris Corporation-Farinon Division, TIA, and UTC at 4 (filed on May 15, 1995)(hereafter "Further Reply").

constraint on the railroads' ability to establish and maintain communications systems at specific geographic points presents a serious risk to system reliability and safety.

Loral's Opposition was equally flawed in its failure to respond to FS concerns. First Loral attempted to raise a procedural objection to AAR's Petition by claiming that AAR "seeks relief which the Commission cannot provide within the context of the WRC-Preparatory Proceeding."[10] The Commission itself raised the issue, however, when it noted the FS parties' concern "about the effect new feeder link operations would have on their current operations and on the ability to accommodate fixed service growth in bands in the 6 GHz, 11 GHz and 18 GHz ranges."[11] In response to these concerns the Commission specifically stated that,

> [w]e are taking into account current and future operations of existing use of bands that we propose to designate for NGSO MSS feeder link use...we intend to ensure that the current and expected relocation negotiations between 2 GHz PCS licensees and incumbent 2 GHz microwave licensees are not disrupted. To this end, we plan to give priority in the 6 GHz and 11 GHz bands to relocated 2 GHz microwave licensees during a reasonable period of time.[12]

Because the Commission itself raised the issue, AAR's request for clarification is both appropriate and timely. Currently plans are being developed for expansion and negotiations are taking place between the FS and PCS users that could be directly and detrimentally impacted by this allocation. Guidance is essential. While a future rule making proceeding may develop the exact specifications of the transition, the fact

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[10] Loral Opposition at 3 (filed August 10, 1995).

[11] Preparation for International Telecommunication Union World Radiocommunication Conferences, Report in IC Docket No. 94-31, FCC 95-256 (June, 1995) at ¶ 52 (hereafter "Report").

[12] Id. at ¶ 53.

of ongoing negotiations and current plans for expansion necessitates a clearer commitment to both FS users and the PCS industry at the present time. Without such a commitment and further clarification, incumbents at 6 GHz and those facing Commission-mandated displacement from the 2 GHz band, as well as PCS systems who are now negotiating the details of relocation arrangements with 2 GHz FS incumbents, are left in a state of regulatory limbo.

Loral also argued that AAR "has provided no technical basis for reconsideration."[13] This argument ignores AAR's discussion regarding band congestion and the fact that numerous previous studies have shown that density of band occupation is of crucial importance in evaluating the technical feasibility of band sharing.[14] Indeed, the CPM Report itself specifically stated that "in general, sharing between FS stations and NGSO/MSS earth stations is feasible in those bands not densely occupied by the FS."[15] The CPM also stated that "it may be possible to identify bands below 10 GHz which are lightly occupied by FS to accommodate non-GSO/MSS feeder links."[16] Thus, as the Statement of Non-Concurrence pointed out, the only fair conclusion from the existing body of technical analysis on which the CPM Report was based is that bands which are densely occupied, such as the 6 GHz band, are not suitable candidates for co-primary sharing with MSS.

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[13] Loral Opposition at 4.

[14] Technical analysis, supra note 5; CPM Report.

[15] CPM Report at 61, ¶ 3.6.6.3 (emphasis added).

[16] Id. at 56, ¶ 3.6.4.3 (emphasis added).

In addition, the FS community has already pointed out in an earlier joint filing that, "the criteria used under Part 25 of [the Commission's] Rules to calculate interference from satellite facilities into FS facilities are much less protective than the criteria under Parts 21 and 94 to protect FS facilities."[17] The Commission itself explicitly noted that additional studies would be "needed to address specific fixed service concerns."[18] In fact, even Constellation in its Opposition acknowledged that there could be interference from "the terrestrial fixed service into the feeder link earth station receivers,"[19] thus necessitating constraints on the geographic placement of FS facilities. Because these technical concerns regarding the feasibility of sharing have yet to be adequately addressed by the MSS proponents, AAR's call for caution in making an allocation at 6 GHz to MSS feeder links was well grounded.

Conclusion

The Oppositions filed by Loral and Constellation fail to respond to the legitimate concerns of AAR and others in the FS community. The FS interests, both users and manufacturers, have documented in numerous filings in this proceeding the problems with sharing at 6 GHz and the need for the Commission to protect not only the interests of the FS users, but also the interests of the PCS and MSS companies who plan to operate at 2 GHz and who will be paying the bill for the relocation of 2 GHz FS incumbents. Accordingly, for the foregoing reasons, AAR respectfully requests the

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[17] Further Reply at 5.

[18] Report at ¶ 54.

[19] Constellation Opposition at 2.

Commission to dismiss the Oppositions of Loral and Constellation and to grant AAR's Petition for Partial Clarification and Reconsideration.

Respectfully submitted,

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August 21, 1995

Attachment: Analysis of FCC Docket IC 94-31: Interference from Mobile Satellite Feeder Links Into Terrestrial Point-to-Point Microwave

## CERTIFICATE OF SERVICE

I, Marilyn Charles, hereby certify that on this 21st day of August, 1995, copies of the foregoing "Consolidated Reply to Oppositions to Petition for Partial Clarification and Reconsideration" were mailed, postage prepaid, to the following:

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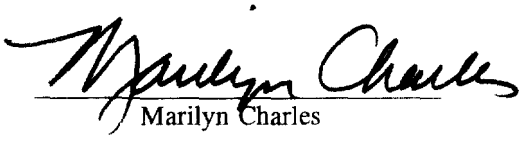

Marilyn Charles

## Analysis of FCC Docket IC 94-31[1]

### Interference from Mobile Satellite Feeder Links into Terrestrial Point-to-Point Microwave

Recently, the FCC, in Docket No. IC 94-31, proposed that feeder links for Mobile Satellite Services (MSS) share spectrum with the terrestrial fixed microwave (FS) services in the upper 6 GHz, 11 GHz, and 18 GHz bands.

There are two types of MSS systems -- geostationary and non-geostationary. The first type uses conventional satellites in geostationary orbit to communicate with mobiles on the ground. There are several geostationary systems currently in operation, and the FCC wants to allocate additional spectrum to this service. The second type uses a large number of satellites in non-geostationary orbits (typically 500 miles up). For example, the Motorola Iridium system proposes 66 satellites, in 6 orbital planes of 11 satellites each, with each plane separated by 60 degrees in longitude. Non-geostationary systems can carry more traffic than geostationary systems, and use lower power for the mobile transmitters.

Both MSS systems require four separate frequency bands to operate: subscriber uplinks and downlinks ("service links"), feeder uplinks, and feeder downlinks. The subscriber links communicate between the satellite and mobiles on the ground. Feeder links are used to carry traffic from the terrestrial network to satellites, to allow scarce 2 GHz frequencies to be reused in different geographical regions. MSS providers in the U.S. have proposed several different frequency bands near 2 GHz for service links, including 1.5-1.7 GHz, 2.0-2.2 GHz, and 2.48-2.5 GHz.

### Proposed MSS Feeder Links in the Upper 6 GHz Band

1. Geostationary Feeder Links

Figure 1 shows the proposed feeder links in the upper 6 GHz band (6.525-6.875 GHz). The FCC wants to add geostationary satellite uplinks in the band segment from 6.725-6.875 GHz. This segment covers about half of the upper 6 GHz band. Since most point-to-point microwave systems are 2-way, and frequencies in the upper half of the band are paired with frequencies in the lower half, this proposal would affect the entire upper 6 GHz band.

Currently, the entire lower 6 GHz band (5.925-6.425 GHz) is used for FSS satellite uplinks. Terrestrial systems successfully have shared the lower 6 GHz band with FSS

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[1]This technical analysis was prepared by the microwave radio engineering staff of Alcatel Network Systems, Inc.

uplinks for many years. The FCC proposal for FSS uplinks in the upper 6 GHz band is identical to the current lower 6 GHz frequency sharing, and uses the same interference specifications. **As a result, frequency sharing with FSS uplinks should not present a problem in the upper 6 GHz band.**

2. Non-Geostationary Feeder Links (LEO Links)

The FCC proposed the overlapping frequency range from 6.825-7.075 GHz for non-geostationary satellite downlinks, using a new concept called "reverse band working (RBW)." RBW allows uplinks and downlinks to be transmitted within the same spectrum. The FCC proposal covers 50 MHz of the Part 21/94 upper 6 GHz band, and will affect the availability of 2x50=100 MHz of point-to-point spectrum (28% of the band). The FCC also is attempting to obtain 150 MHz in the adjacent Part 74/78 Broadcast Auxiliary/Cable TV Relay Band (6.875-7.125 GHz) for non-geostationary feeder downlinks. This adjacent band is used for studio-transmitter and mobile television links.

The FCC anticipates requiring additional spectrum for MSS feeder links. Therefore, if the FCC is successful in obtaining spectrum in either of the affected bands, it likely will seek reallocation of even more spectrum. It appears that more of the Part 74/78 broadcasting band is affected than the Part 21/94 point-to-point band.

Currently, three U.S. companies have been approved for non-geostationary orbit systems: Motorola, TRW, and Loral/Qualcomm. Loral/Qualcomm is the only licensee proposing to use the upper 6 GHz band for feeder links. It requested the frequency range from 6.875-7.025 GHz for downlinks, which totally avoids the Part 21/94 upper 6 GHz band. The FCC appears to have lowered the Loral/Qualcomm band edge by 50 MHz to 6.825 GHz, to obtain spectrum for "future growth."

ITU, in its Document CPM95/119-E, studied frequency sharing between terrestrial FS and non-geostationary downlinks. It concluded that sharing is possible, and that the probability of simultaneous interference from multiple satellites is low. However, the paper also stated that sharing should not be done in frequency bands with heavy use of FS. Since the non-geostationary satellite is moving, there is a much greater probability of interference into the main beam of FS.

Upper 6 GHz is becoming the preferred band for low capacity terrestrial systems in the U.S. These low capacity systems have very low receiver thresholds, which are particularly susceptible to satellite interference.

There will be relatively few earth stations in the band (e.g., 10 to 15 in the U.S.). However, these earth stations will be difficult to frequency coordinate. The ITU calculated a maximum coordination distance of 700 kilometers (435 miles) for downlinks in the 6 GHz band. Coordination will generally have to be done for the whole frequency band, over a much wider range of azimuth angles than a geostationary earth station. It will be important to site the earth stations in remote areas, with adequate terrain or man-

made shielding. As the MSS service grows, it is likely that additional earth stations will be required in the future.

**Interference from non-geostationary satellite downlinks is a potentially serious problem in the upper 6 GHz band. This interference may cause unacceptable interference into existing equipment in the field. The 50 MHz of spectrum affected may become unusable in the future, impacting the frequency availability of 28% of the band. The band edge should be changed from 6.825 GHz to 6.875 GHz.**

**Proposed MSS Feeder Links in the 11 GHz Band**

1. Geostationary Feeder Links

Figure 2 shows the proposed feeder links in the 11 GHz band (10.7-11.7 GHz).

Currently, the band segments from 10.95-11.2 and 11.45-11.7 GHz are shared with international FSS downlinks (i.e., INTELSAT). There are relatively few earth stations in the U.S., and the earth stations that do exist tend to be in remote areas well shielded by terrain. As a result, frequency coordination between terrestrial and FSS systems in the 11 GHz band has not been a problem in the past. It has been more difficult to coordinate with some recently constructed earth stations, which have been sited in urban areas (e.g., teleports). However, it is usually possible to select terrestrial frequencies in the unshared portions of the 11 GHz, when there are coordination problems.

The FCC wants to add FSS downlinks in the unshared band segments, from 10.7-10.95 and 11.2-11.45 GHz. These segments of the band will not be restricted to the international FSS service and could be used for any authorized domestic satellite use. As a result, it is likely that these segments of the band will become increasingly difficult to coordinate over time as additional earth stations are installed. This same problem has occurred in the 4 GHz band. In cases of frequency congestion, it may be possible to select terrestrial frequencies in the international satellite segments of the band.

**The FCC FSS downlink proposal will place one-half of the 11 GHz band at risk of becoming another 4 GHz. Even if this occurred, there would be at least six 30 MHz channels available in the other half of the band. The 11 GHz band would not be lost, but would be more difficult to use. If this proposal cannot be blocked, restrictions on the use of the spectrum by fixed satellite users (e.g., to prevent unlicensed earth stations, like in the 4 GHz band) should be pursued.**

2. Non-Geostationary Feeder Links (LEO Links)

The FCC proposes NG-MSS uplinks in the same two band segments as the geostationary downlinks described in Section 1. above. The ITU calculated the

maximum coordination distance as 415 kilometers (258 miles) for 11 GHz uplinks, which is not as severe as the 6 GHz downlinks. However, NG-MSS uplinks will be more difficult to frequency coordinate than FSS uplinks, since a much wider range of azimuth angles must be considered. Many 11 GHz terrestrial paths are in urban areas. To successfully coordinate with existing paths, earth stations may be forced into remote areas with adequate terrain shielding. This will help future terrestrial coordinations.

**The non-geostationary uplink proposal will further complicate the frequency coordination of the 10.7-10.95 and 11.2-11.45 GHz band segments.**

**Proposed MSS Feeder Links in the 18 GHz Band**

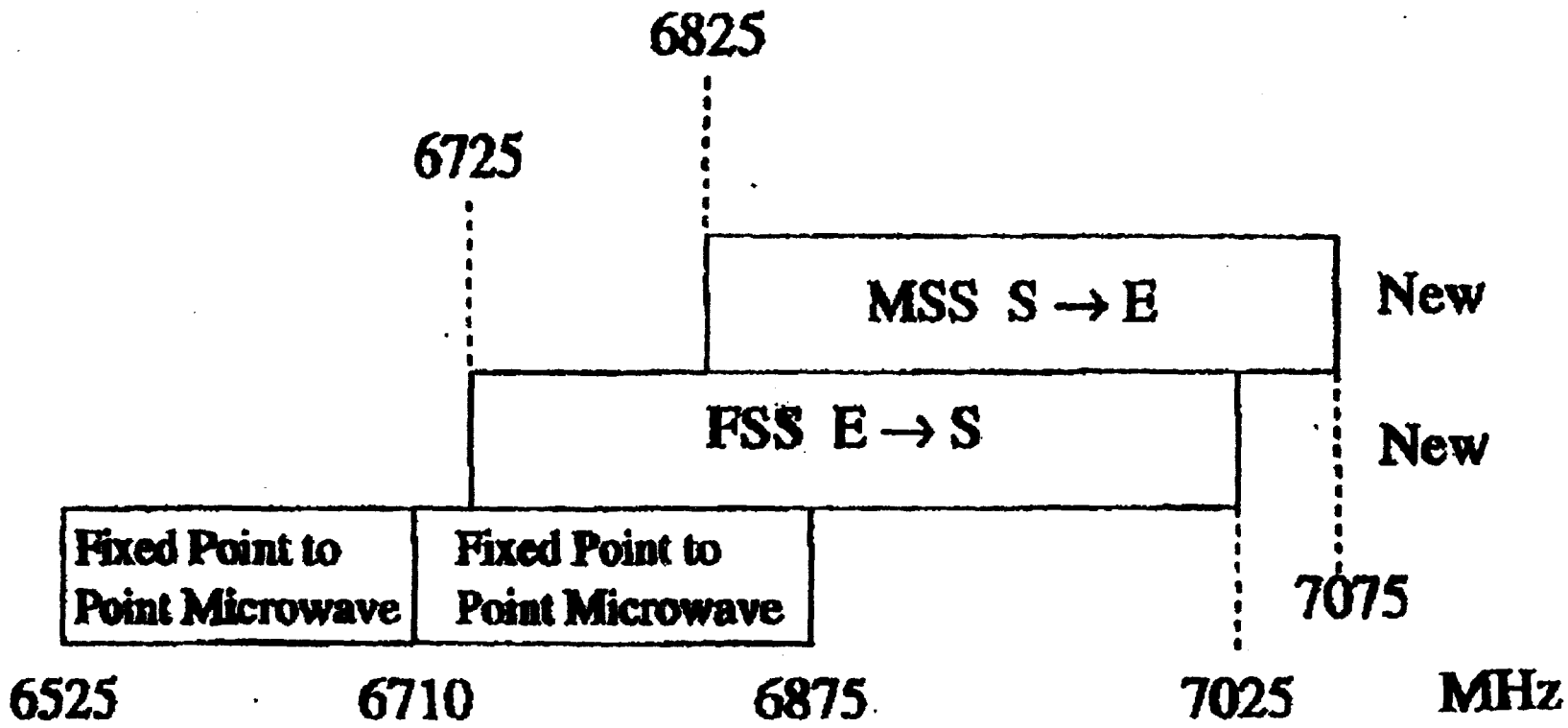
1. NG-MSS Feeder Links (LEO Links)

Figure 3 shows the proposed feeder links in the 18 GHz band (17.7-19.7 GHz).

Currently, FSS satellite downlinks are permitted between 18.8 and 19.7 GHz. The FCC proposal would allow NG-MSS uplinks between 18.9 and 19.2 GHz. This proposal would affect 35% of the 10 MHz channels in the 18 GHz band. MSS providers will probably be forced to locate earth stations outside urban areas, to avoid interference into existing 18 GHz terrestrial paths. The ITU maximum coordination distance is about 200 kilometers, or 125 miles, which is about the same as the coordination distance between terrestrial paths.

# Upper 6 GHz
# (Part 21/94)

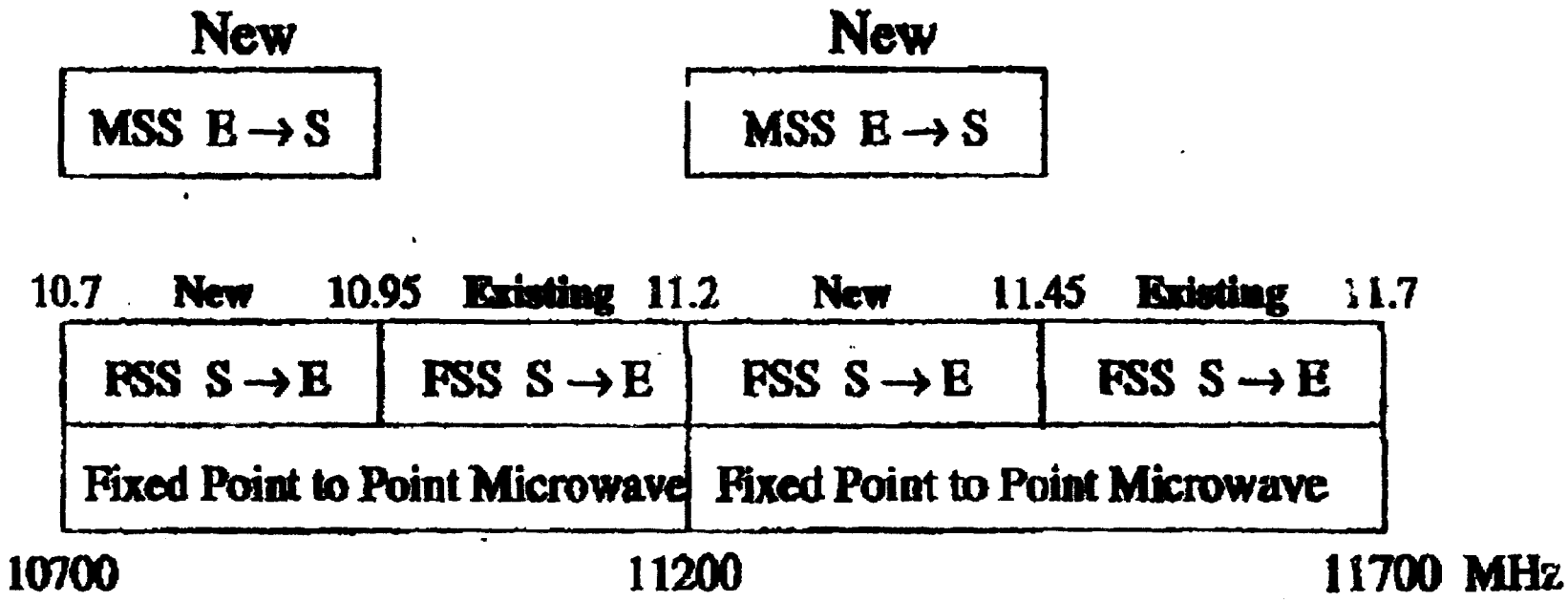
FIGURE 1




| | | |
|---|---|---|
| MSS | = | Mobile Satellite Service (Non-Geostastionary Satellite Orbit) |
| FSS | = | Fixed Satellite Service (Geostationary Satellite Orbit) |
| E → S | = | Earth to Space (earth transmitters) |
| S → E | = | Spdce to Earth (earth receivers) |

# 11 GHz
# (Part 21/94)

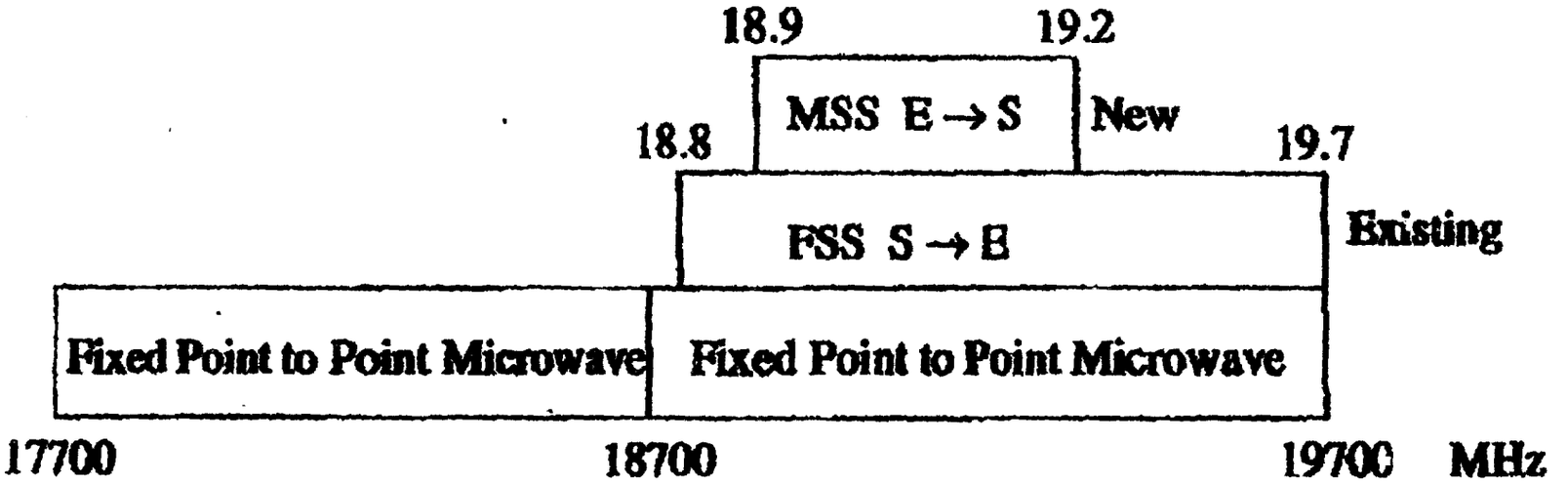
FIGURE 2




| | | |
|---|---|---|
| MSS | = | Mobile Satellite Service (Non-Geostationary Satellite Orbit) |
| FSS | = | Fixed Satellite Service (Geostationary Satellite Orbit) |
| E → S | = | Earth to Space (earth transmitters) |
| S → E | = | Space to Earth (earth receivers) |

# 18 GHz
# (Part 21/94)

FIGURE 3




| | | |
|---|---|---|
| MSS | = | Mobile Satellite Service (Non-Geostationary Satellite Orbit) |
| FSS | = | Fixed Satellite Service (Geostationary Satellite Orbit) |
| E → S | = | Earth to Space (earth transmitters) |
| S → E | = | Space to Earth (earth receivers) |

## Analysis of NGSO MSS Feeder Link Interference into Terrestrial Point-to-Point Links

FCC Draft Proposal No. 1/FL-MSS, MOD 2567(b) specifies a maximum power flux density (pfd) of -154 dB ($W/m^2/4$ kHz) for arrival angles between $0^0$ and $5^0$ for non-geostationary satellite downlinks operating between 6525-7075 MHz. This band overlaps the top 50 MHz of the FCC Part 21 Common Carrier and Part 94 Operational Fixed allocations in the 6525-6875 MHz band. The following calculations show the significant performance degradation of a single satellite interference into a high capacity 1-DS3 terrestrial point-to-point radio. Radio specifications are typical of products offered in the U.S.

The trend for U.S. radio manufacturers is to offer radios with higher spectral efficiency, employing advanced modulation methods like 64-QAM (quadrature amplitude modulation) and 128-TCM (trellis-coded modulation). This trend was further encouraged by the recent FCC rule changes in Part 21 and Part 94, which specify minimum spectral efficiency for all frequency bands between 4 and 11 GHz. Spectral efficiency requirements are generally more stringent in the U.S. than in other countries. Radios with higher spectral efficiency are more susceptible to satellite interference.

Example

| | | |
|---|---|---|
| Manufacturer: | Alcatel Network Systems | |
| Model: | MDR-4106e-CN | |
| FCC Identifier: | JPM-8609 | |
| Capacity: | 1-DS3 | (digital) |
| Modulation: | 64-QAM | |
| Bandwidth: | 10 MHz | |
| Antenna: | 12 foot parabolic | (3.7 meter diameter) |
| Misc. Losses: | 2 dB | (feeder/branching) |

Assume a co-channel interference into the MDR-4106e-CN, with no antenna discrimination, and a satellite transponder bandwidth of 16.3 mHz:

| | |
|---|---|
| I = -154.0 dBW/$m^2$/4 kHz | Maximum Interference from the satellite |
| 30.0 dB | Conversion from dBW to dBM |
| -124.0 dBM/$m^2$/4 kHz | |
| 10.3 dB | Antenna area = 10 $Log_{10}(PI \times (3.7/2)^2)$ |
| -2.6 dB | Assume 55% parabolic efficiency = 10 $Log_{10}(.55)$ |
| -116.3 dBM/ 4 kHz | |
| 34.0 dBM/10 mHz | Noise Bandwidth ratio = 10 $Log_{10}(10000/4)$ |
| - 82.3 dBM/10 mHz | |
| -2.0 dB | Feeder/branching Losses |
| - 84.3 dBM/10 mHz | Interference level into the receiver in dBM |

Assume that the terrestrial path has a 35 dB thermal fade margin to the $10^{-6}$ bit error rate receiver threshold. Most cellular providers and other microwave operators carrying data traffic normally use the $10^{-6}$ bit error rate threshold.

| | | |
|---|---|---|
| T | = -75.0 dBM | MDR-4106e-CN receiver threshold ($10^{-6}$ bit error rate) |
| | 35.0 dB | Thermal fade margin |
| C | = -40.0 dBM | Normal received signal level |
| I | = -84.3 dBM | Interfering power level from the satellite |
| $C/I_1$ | = 44.3 dB | Carrier-to-Interference (co-channel) |
| $C/I_2$ | = 24.0 dB | MDR-4106e-CN C/I for continuous $10^{-6}$ bit error rate |
| EIFM | = 20.3 dB | External Interference Fade Margin |

$FFM = -10 \log_{10} (10^{-20.3/10} + 10^{-24.3/10}) = 20.2$ dB  Flat Fade Margin

Threshold Degradation = 35 - 20.2 = 14.8 dB

Assuming that the effects of channel dispersion are insignificant, the multipath outage time without frequency or space diversity is:

$$T = R\,T_o \times 10^{-FFM/10}$$

where R is a function of path length, frequency, climate, and roughness and $T_o$ depends on the length of the fading season. The performance degradation due to the interference is:

$$T_1 / T_2 = 10^{-FFM1/10} / 10^{-FFM2/10} = 10^{-20.2/10} / 10^{-35/10} = 30.2, \text{ or: } 3020\%$$

This percentage assumes that the satellite interference is received continuously during terrestrial fading events. The actual performance degradation will depend on the amount of time the terrestrial path is fading and receiving satellite interference, simultaneously. Some paths oriented along the satellite orbit will receive interference for large percentages of the time. Other paths oriented away from the orbit will be protected by antenna discrimination.

Paths affected by ground reflections, subrefractive fading, or other long-duration fading events will be particularly susceptible to satellite interference. These long-duration fading events may cause signal depressions of 20 dB or more for minutes (or hours). Satellite interference will reduce the effective fade margin of these paths, substantially increasing the probability of multipath outages. For example, paths in the southeastern United States are often affected by severe fading activity. Paths oriented in a north-south direction near the Gulf of Mexico will be exposed to interference from polar orbiting satellites as they clear the horizon over the Gulf.

Microwave operators demand very high path reliability (e.g., 99.999% or higher). The microwave paths in the 6 GHz band may be used by state and local governments for emergency communications, electric utilities to protect their transmission networks, gas pipeline operators to control pumping stations, or cellular operators to connect switching facilities to remote base stations. These microwave operators are not using fiber optics or other leased facilities because they cannot tolerate outages due to cable cuts or other service interruptions. Intermittent outages due to satellite interference are totally unacceptable to these users.

PCS providers have paid the Federal Government $7 billion for spectrum in the 1850-1990 MHz segment of the band, and need to relocate the incumbent 2 GHz microwave users to other bands in order to construct their networks. The 6 GHz band will be the most heavily used band for relocations, since it can support long path lengths, and is not affected by rain outage like the higher frequency bands. Under the FCC rules, PCS providers must provide comparable facilities to the 2 GHz microwave operators, or else they must pay to relocate the microwave operators back to 2 GHz. PCS providers will also use the 6 GHz band in their own networks for cell interconnects, particularly in suburban and rural areas. In the future, the 2110-2200 MHz segment of the band may be reallocated to MSS services. The incumbent microwave operators in this band may also require relocation to other bands.

ITU, in its document CPM95/118-E, discusses the sharing of spectrum between terrestrial fixed services and MSS feeder links. The document states that sharing should be done in lightly loaded terrestrial frequency bands. The 6 GHz band is heavily loaded now and will be even more heavily loaded when all 2 GHz relocations are performed, and cellular and PCS providers build out their networks.

References:


1. A. Vigants, "Space Diversity Engineering", Bell System Technical Journal, January 1975, pp. 103-142.

2. W. D. Rummler, "A Comparison of Calculated and Observed Performance of Digital Radio in the Presence of Interference", IEEE Transactions on Communications, July 1982, pp. 1693-1700.

## Analysis of Interference between Terrestrial Point-to-Point Links and 4 GHz Geostationary Receive Earth Stations

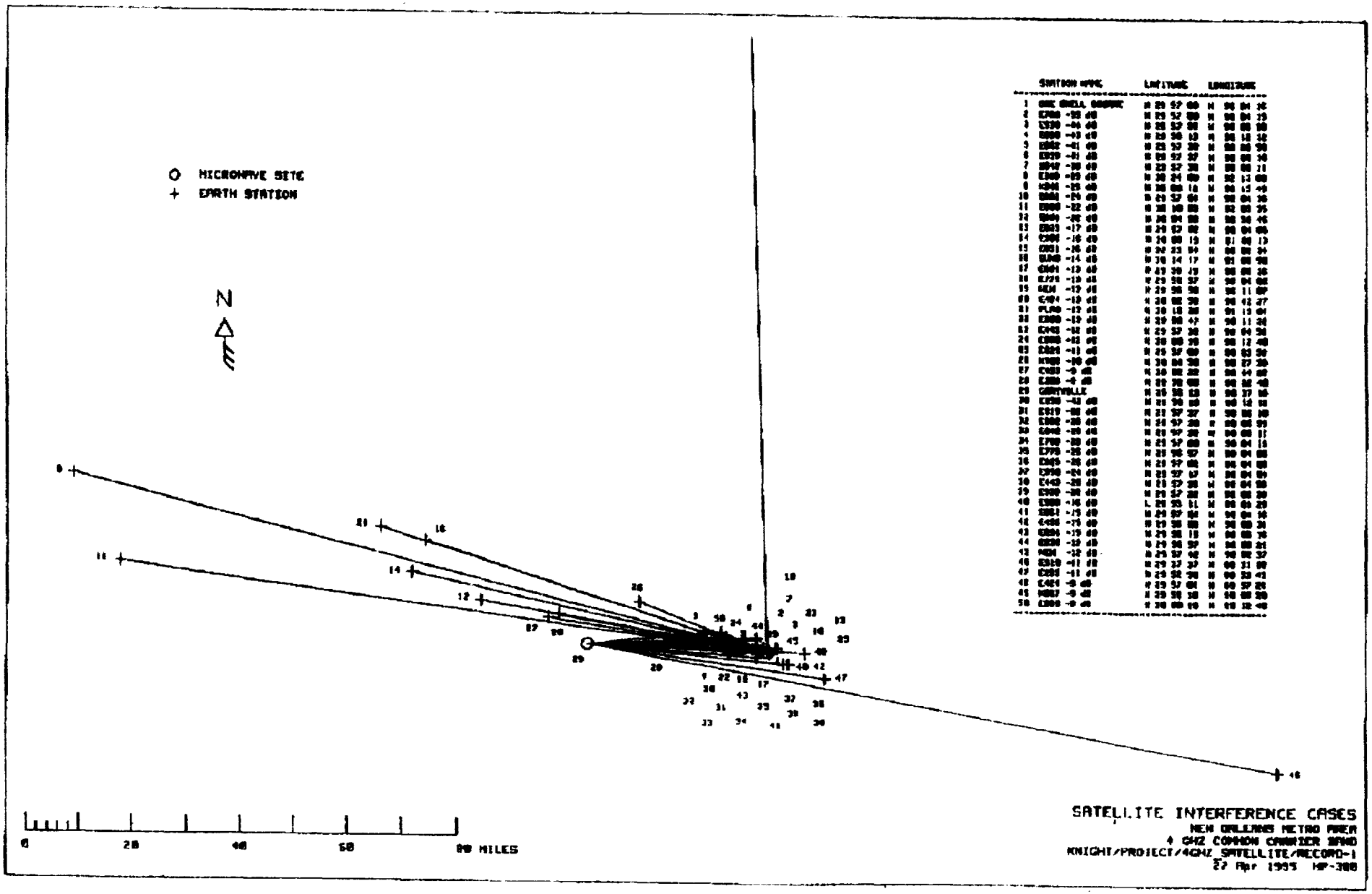
To demonstrate frequency coordination problems between terrestrial point-to-point systems and geostationary receive earth stations, Alcatel attempted to coordinate two 4 GHz terrestrial paths in typical metropolitan areas. New Orleans and Minneapolis were selected as test cities. The study was performed using the Comsearch frequency data base.

Figure 1 shows the results of the New Orleans coordination. The site locations and antenna heights of an existing lower 6 GHz microwave path from One Shell Square to Garyville were used for the test path, assuming 4 GHz antennas and radio equipment. A total of 48 interference cases were identified that exceeded the minimum earth station interference criteria. Each line on the plot shows an interference path. The table on the right lists the affected earth stations and the severity of each interference case in dB. The worst cases were 55 and 44 dB above the minimum acceptable interference.

Figure 2 shows the results of the Minneapolis coordination. An existing cellular path from Loretto to MTSO was used as the test path. The coordination identified 30 interference cases. The worst cases were 42 and 39 dB above the interference limit.

Alcatel's experience has been that it is virtually impossible to coordinate 4 GHz terrestrial paths in metropolitan areas in the U.S. To clear interference cases, it may be necessary to perform expensive field surveys to measure local shielding. Outside of metropolitan areas, microwave operators are reluctant to use 4 GHz due to the large number of unlicensed earth stations owned by consumers. Although the unlicensed earth stations are not protected against interference, owners tend to be very vocal about interference problems and may hold positions of authority in local governments, zoning boards, etc.

Alcatel is concerned that if the 11 GHz band is allocated to geostationary downlinks, the band may become unusable to point-to-point microwave (like the 4 GHz band). The 11 GHz band is the only other band besides lower 6 GHz with 30 MHz channels available, that can carry 2 or 3 DS3 capacity per RF carrier. The 11 GHz band is heavily used in metropolitan areas, when the lower 6 GHz band is unavailable due to frequency congestion. Higher bands like 18 GHz have excessive rain outage for these applications.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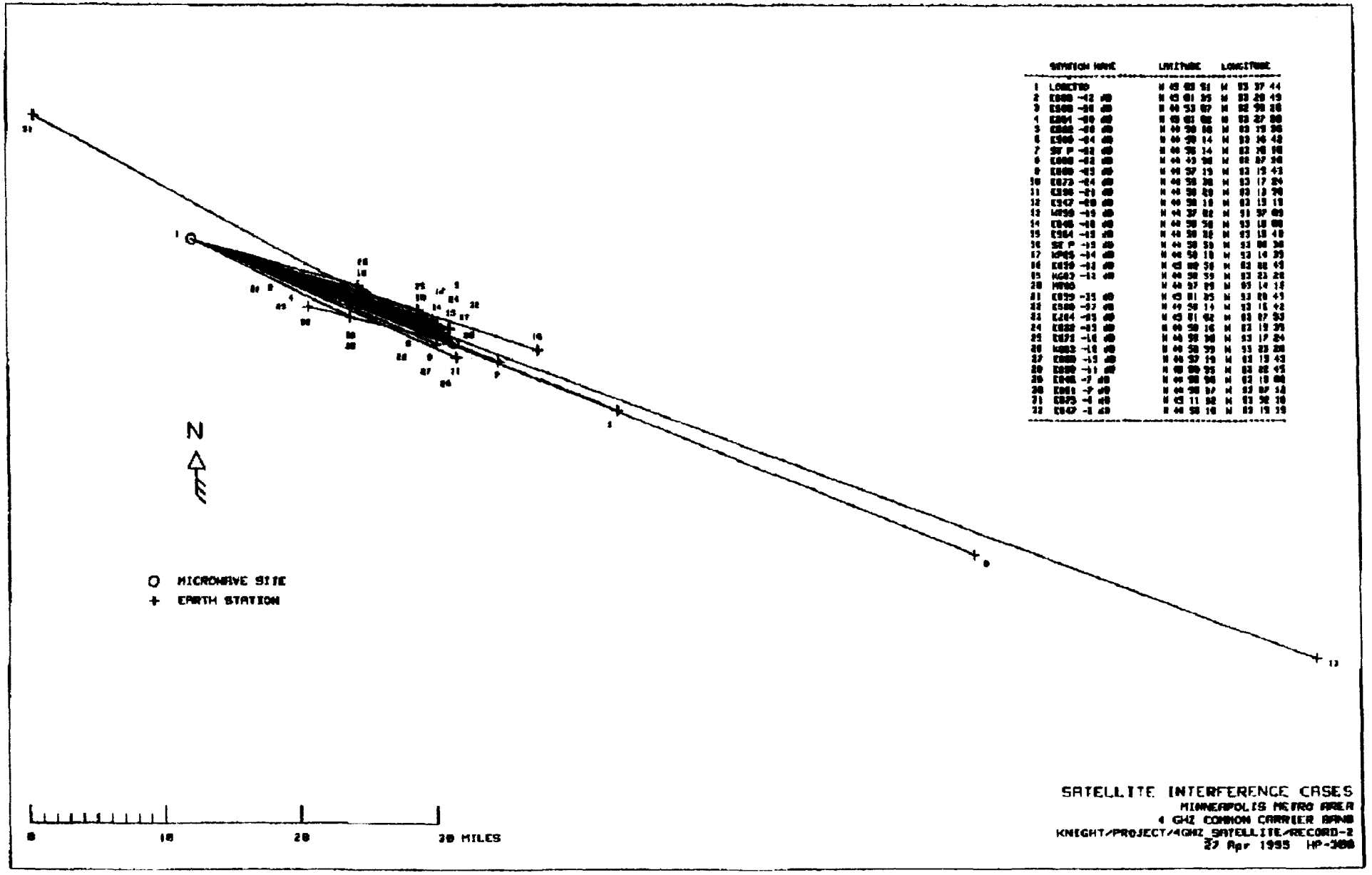
SATELLITE INTERFERENCE CASES
NEW ORLEANS METRO AREA
4 GHZ COMMON CARRIER BAND
KNIGHT/PROJECT/4GHZ_SATELLITE/RECORD-1
27 Apr 1995 HP-300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4 GHz COMMON CARRIER BAND
KNIGHT/PROJECT/4GHZ_SATELLITE/RECORD-2
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## Statistical Data for the 2 GHz Bands

Attached is a table listing the number of licensed microwave frequencies in the 2 GHz band. The table was taken from the FCC Office of Engineering and Technology report, "Creating New Technology Bands for Emerging Telecommunications Technology" (OET/TS 91-1). This document was used in the PCS proceeding to identify available frequency bands.

The following is a summary of the Part 21 Common Carrier and Part 94 Operational Fixed bands involved in the reallocation proceedings. Some or all of these systems may be relocated to other frequency bands in the future.

| Frequency Band MHz | Service | Number of Frequencies |
|---|---|---|
| 1850 - 1990 | Part 94 | 9258 |
| 2110 - 2130<br>2160 - 2180 | Part 21 | 6823 |
| 2130 - 2150<br>2180 - 2200 | Part 94 | 13035 |
| Total | | 29116 |